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Adapting bilateral directional processing to individual and situational influences

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Introduction

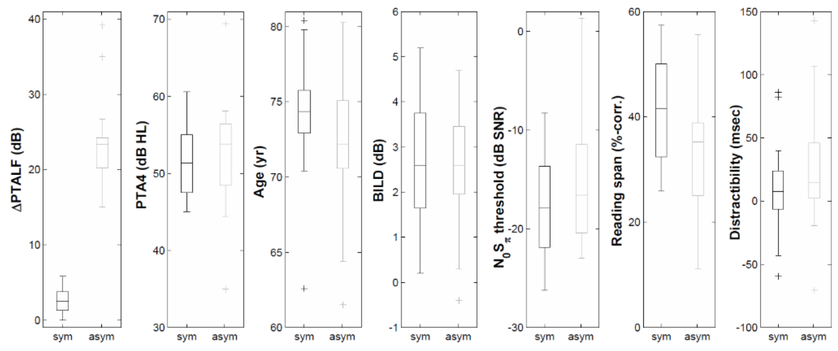
Hearing aid (HA) users can differ markedly in their benefit from directional processing algorithms. The current study (Neher et al, 2017) thus investigated candidacy for different directional processing schemes. In a previous study (Neher, 2017), we screened ~80 elderly hearing-impaired listeners with a large spread in the degree of audiometric asymmetry <2 kHz (ΔPTALF) re. the binaural contribution to speech-in-noise reception (BILD). Here, we tested a subset of these listeners using computer simulations of different HA fittings and acoustic scenarios. Our aims were to:

(1) Relate ΔPTALF and BILD to performance with five directional processing schemes that differed in the trade-off between signal-to-noise ratio (SNR) improvement and binaural cue preservation

(2) Investigate if a simple binaural tone-in-noise detection measure can predict benefit from binaural cue preservation

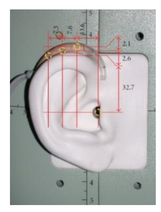
Participants

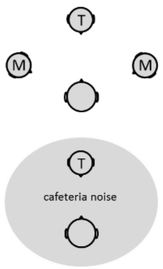
- Groups of listeners with symmetric (N = 20) or asymmetric (N = 19) ΔPTALF, a large spread in the binaural intelligibility level difference (BILD; Kollmeier, 1996), and no difference in age, overall degree of hearing loss (PTA4), N_0S_π detection performance at 500 Hz or distractibility/selective attention (cf. Neher, 2017)



Stimuli

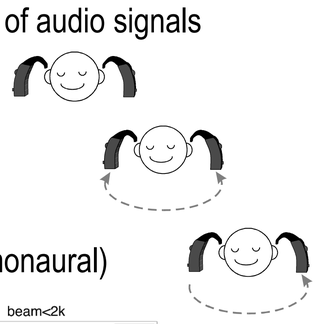
- Virtual acoustics: Head-related impulse responses measured with two behind-the-ear (BTE) HA dummies placed on a head-and-torso simulator (Kayser et al, 2009)
- Target: OlSa sentences (Wagener et al, 1999) from 0° and 1 m
- Maskers:
  - olsa60: OlSa sentences from ±60° (free-field, different speaker)
  - ists60: International Speech Test Signal (Holube et al, 2010) from ±60° (free-field, different speakers)
  - cafnois: Spatially diffuse speech babble with intermittent voices and other noises

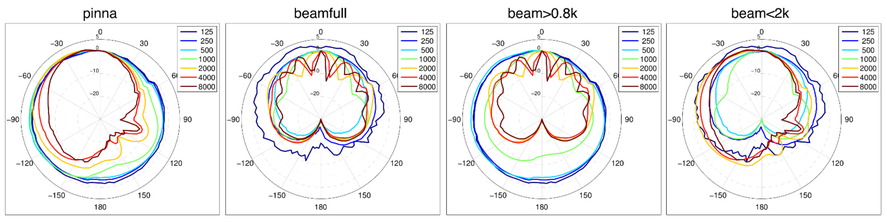




HA conditions

- Simulation of a linked pair of completely occluding BTE devices based on the Master Hearing Aid (Grimm et al, 2006); full exchange of audio signals
  - pinna: Slightly directional >2 kHz (dichotic)
  - beamfull: Highly directional re. 0° (diotic)
  - beam>0.8k: beamfull >0.8 kHz, pinna below (hybrid)
  - beam<2k: beamfull <2 kHz, pinna above (hybrid)
  - beambetter: beamfull with only better ear stimulated (monaural)



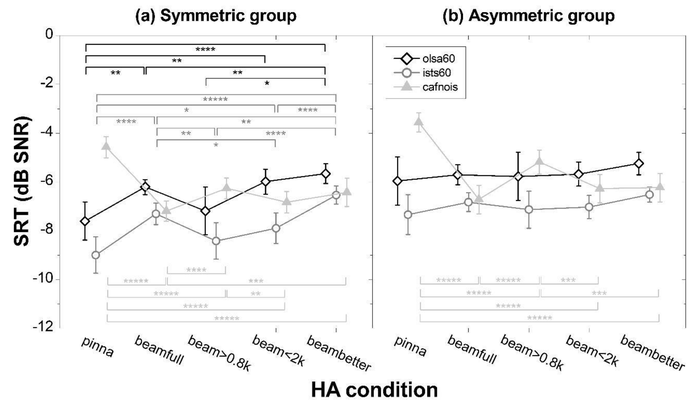


- Speech-weighted SNR improvement (ΔAI-SNR) re. pinna, see table →
- Amplification according to NAL-RP (Dillon, 2012)

HA condition	ΔAI-SNR re. pinna (dB)			
	olsa60	ists60	cafnois	mean
beamfull	4.2	4.8	4.0	**4.4**
beam>0.8k	2.0	2.0	2.3	**2.1**
beam<2k	3.2	3.6	2.6	**3.1**
beambetter	4.2	4.8	4.0	**4.4**

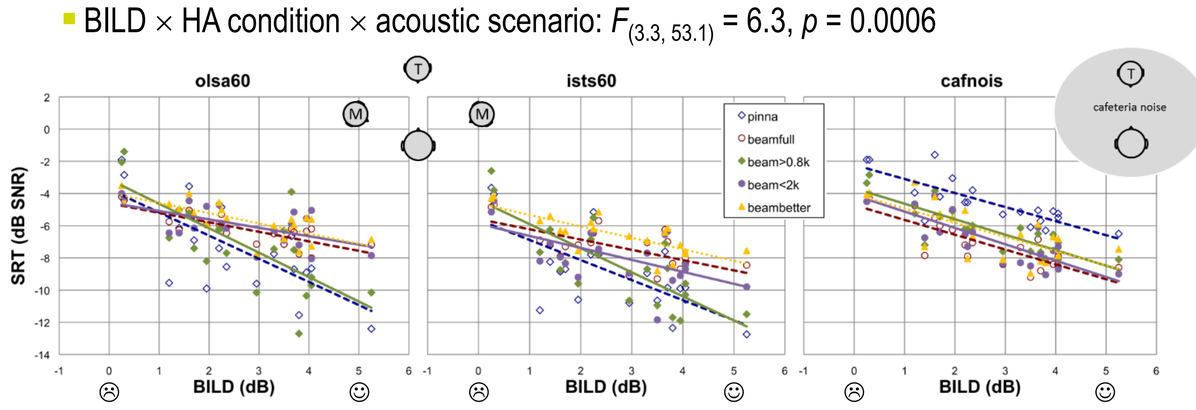
Results

- Speech reception thresholds (SRTs) corresponding to 50%-correct speech intelligibility
- Very good test-retest reliability (all r > 0.73, all p < 0.00001)
- ΔPTALF affects influence of HA condition in olsa60 and ists60 scenarios



Symmetric group

- Repeated-measures ANOVA, main finding:
  - BILD × HA condition × acoustic scenario: $F_{(3.3, 53.1)}$ = 6.3, p = 0.0006



Asymmetric group

- Repeated-measures ANOVA, main finding:
  - BILD × HA condition × acoustic scenario: $F_{(3.7, 55.4)}$ = 3.4, p = 0.016

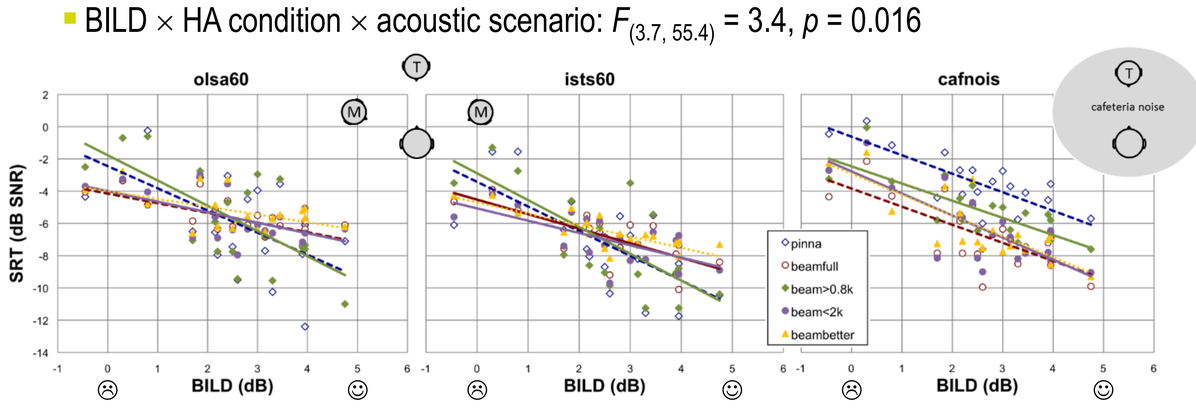
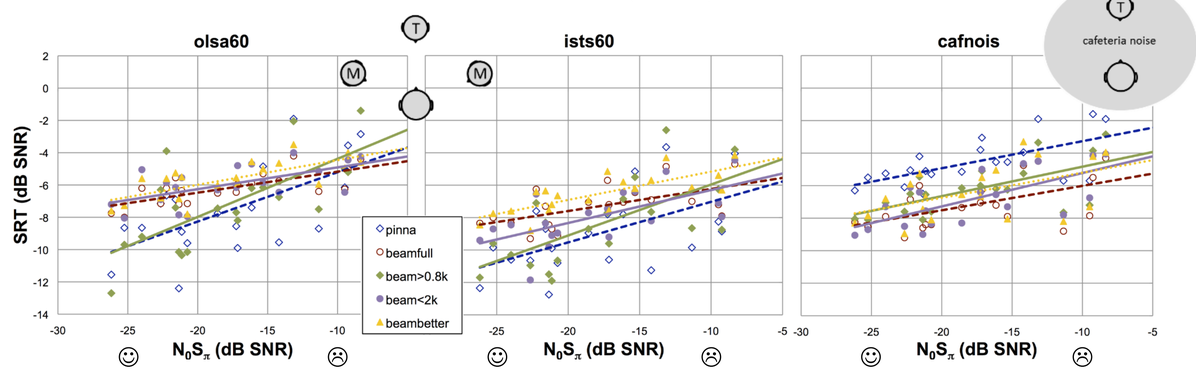


BILD vs. N_0S_π

- BILD and N_0S_π strongly correlated (r = –0.72, p < 0.00001)
- Repeated-measures ANOVA with N_0S_π instead of BILD (data of symmetric group)
  - N_0S_π × HA condition × acoustic scenario: $F_{(3.2, 50.7)}$ = 4.2, p = 0.009



Summary & Outlook

(1) Binaural hearing abilities, audiometric asymmetry <2 kHz and the acoustic scenario influence speech reception with bilateral directional processing

(2) For lateral speech maskers, binaural hearing abilities modulate benefit from preserved low-frequency binaural cues

(3) For spatially diffuse noise, the maximal SNR improvement is beneficial

(4) Audiometric asymmetry <2 kHz reduces the influence of binaural hearing

(5) N_0S_π detection at 500 Hz predicts benefit from low-frequency binaural cues effectively

These findings provide a basis for adapting directional processing to the user and the scenario. Ongoing research investigates their generalizability to clinical HA fittings.

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